Radiometric and spectral inter-comparison of IASI : IASI-A / IASI-B, IASI / AIRS, IASI / CrIS

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OUTLINE

- Introduction
- IASI-A / IASI-B direct inter-comparison by quasi-SNOs
- IASI / CrIS, IASI / AIRS direct inter-comparison by SNOs
- IASI-A / IASI-B inter-comparison via CrIS & AIRS
- IASI-A / IASI-B inter-comparison by massive means
- Conclusions

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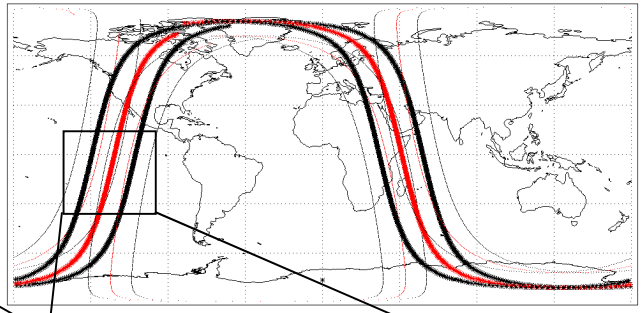
Introduction

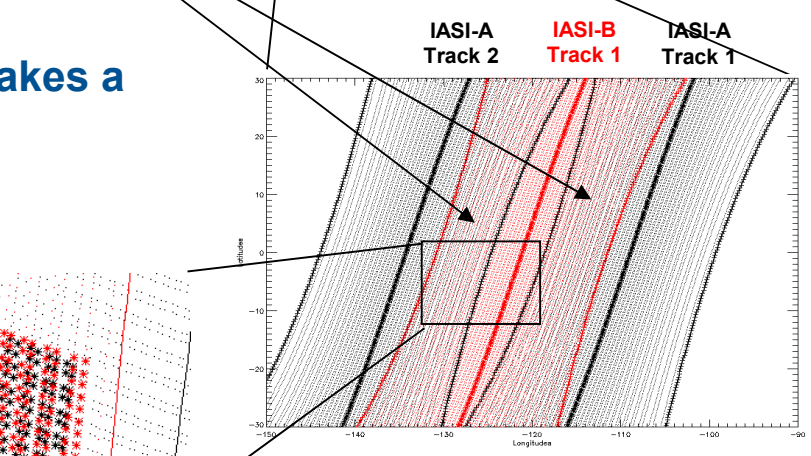
- **Objectives of the inter-comparison**
  - For the IASI TEC: External monitoring of the IASI calibration
    - » Participation to the in-flight commissioning (IASI-B) and routine monitoring (IASI-A and B)
  - For the users (in particular GSICS):
    - » To ensure the consistency of the IASI calibration within the TIR sensors community
    - » To check the long term data quality (climatology)

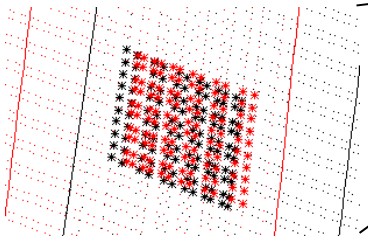
- **Principles:**
  - Observations in normal operations (IASI L1C)
  - Statistics on a very large dataset to detect calibration biases
  - Work by couples :
    - » **IASI-A / IASI-B, IASI-A / AIRS, IASI-B / AIRS, IASI-A / CrIS, IASI-B / CrIS**
  - Focus on same geophysical scenes observed by a pair of two sensors:
    Common observations ~ same place, same time, same viewing conditions
    ➔ Assesses the calibration difference only
  - No correction of spectra by simulation

Methodology for direct IASI-A / IASI-B

- **Similar scenes:**
  IASI-A and B are on the same orbit with a 180° shift
  ➔ Numerous common observations between 2 consecutive tracks, but:
  - » never simultaneous: ~50min temporal shift
  - » off-nadir: from 0° to 39°, opposite angles







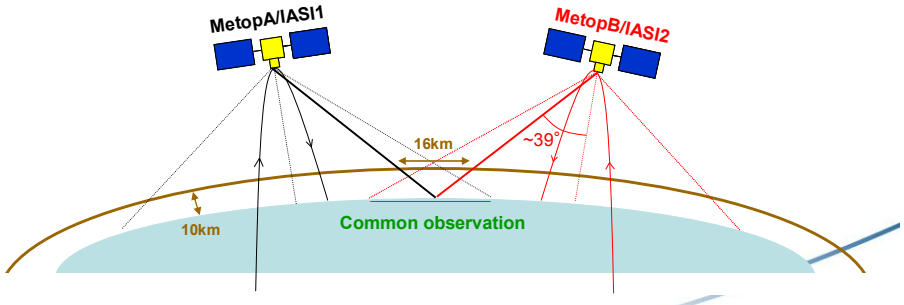
- **The numerous common observations makes a pre-filtering compulsory**
  ➔ **On the most relevant scenes**

- **Spatial match:**
  - ✦ Regional averaging of the soundings (area 300km * 300km or less)

- **Spectral match:**
  - ✦ ΔT calculated at elementary channel level

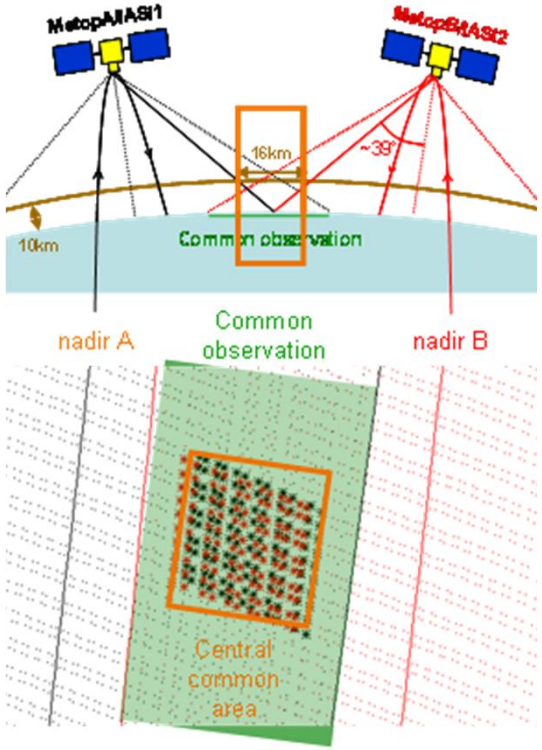
$$\Delta T = \left(L_{IASI-B} - L_{IASI-A}\right) \Big/ \frac{\partial L_\sigma}{\partial T}(\sigma, 280K)$$

➔ Mean and stdev computed over the dataset



IASI-A / IASI-B : selection of scenes

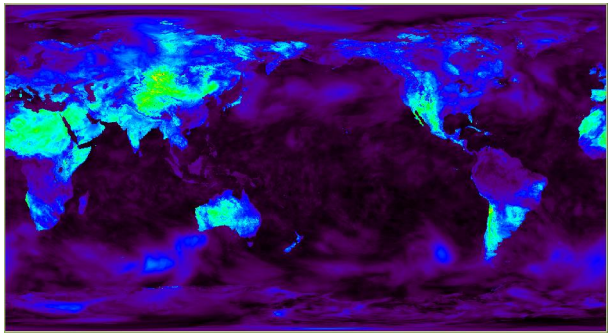
- **Selection aims at reducing the effects of :**
  - **50 min time delay**
    - » Need for stable scenes
    - » Need for homogeneous atmospheres (same atm. even if moving)
  - **Off-nadir geometry** = The lines of sight A & B are always different
    - » Focus on the central area ➔ same atmospheric thickness
    - » Need for homogeneous atmospheres (typical size ~16km)



- **Selection by a relevance index**

Assessment of several parameters, each parameter is given a mark, then a global mark is computed with weights

  - **For homogeneous scenes:**
    - » Low inter-pixel and intra-pixel variance of the IIS imager for A & B
    - » Clouds & snow: none or full in A & B
  - **For stable scenes:**
    - » Focus on oceans at night
    - » Low differences in IIS imager A & B temperatures
    - » Clouds & snow: same amount between A & B
    - » Low variations in ECMWF profiles (“Geophysical NeDT”)

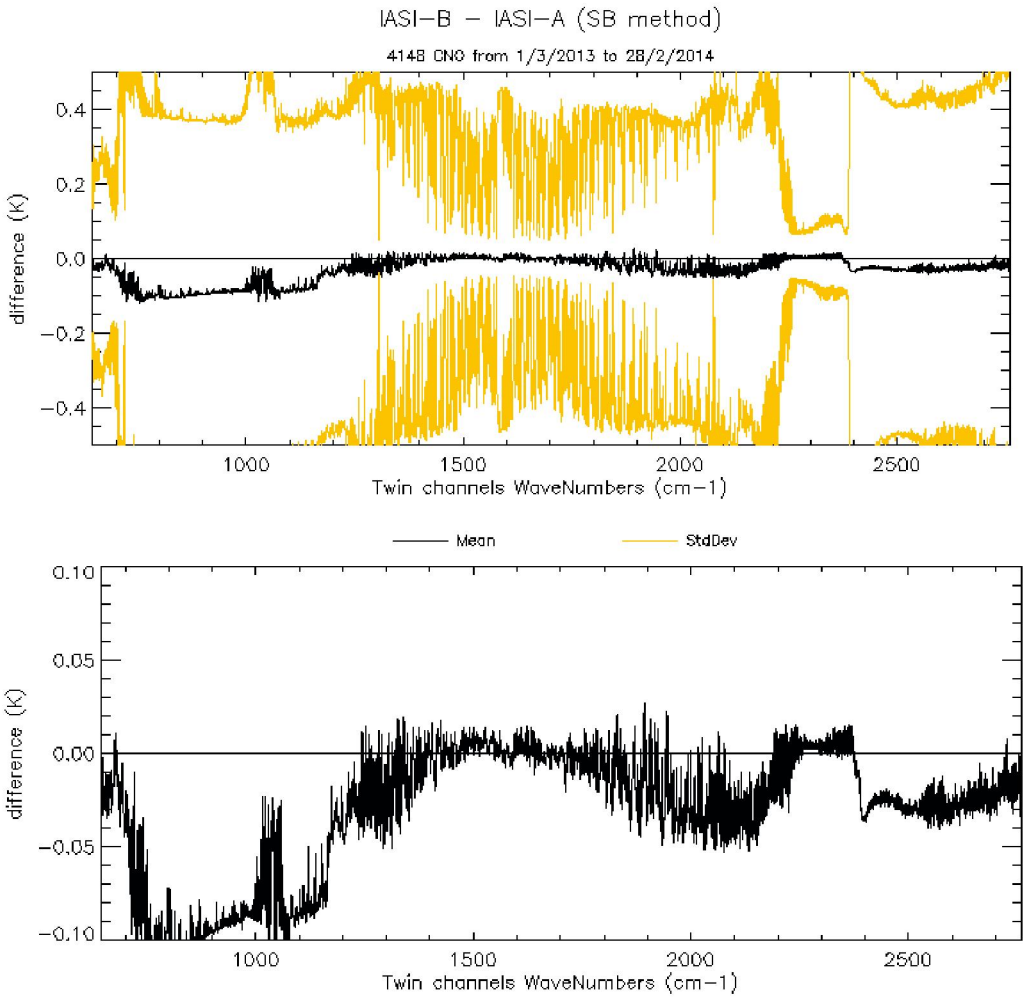


“Geophysical” daily NeDT

0.74K **19.92K**

Direct IASI-A / IASI-B inter-comparison: results

- Biases and standard deviation over the selected dataset (homogeneous and stable scenes, night, as many “A before B” as “A after B”)



With 1 year of data:

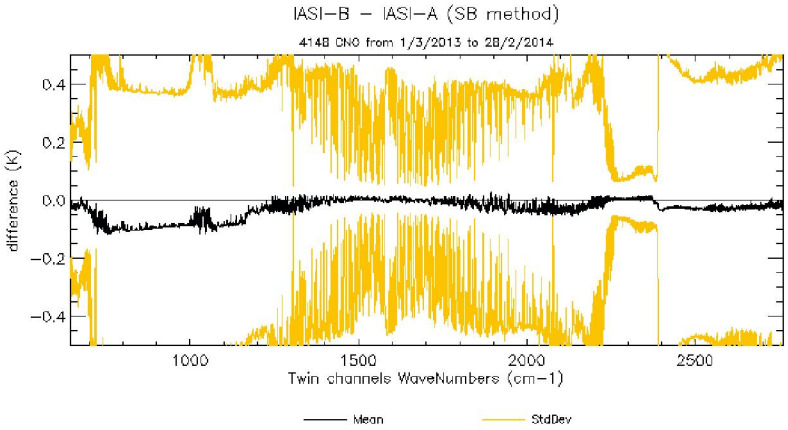
- Biases < ~0.1K

➔ Very good cross calibration

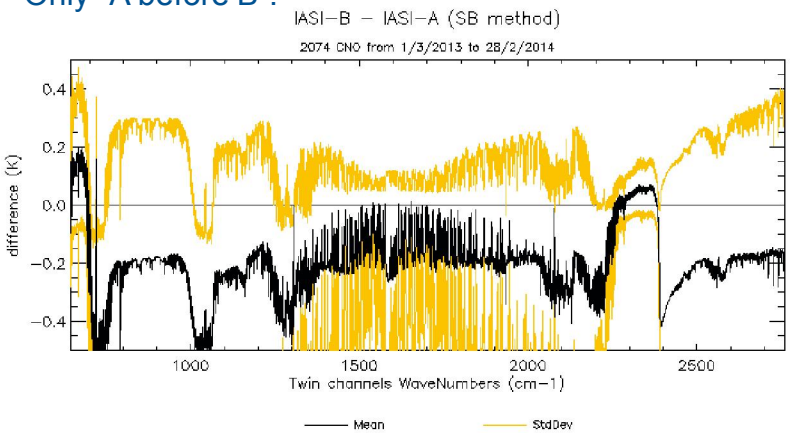
- Compliant with the radiometric absolute specification of 0.5K
- Highest bias in B1
- Shape not understood, still under investigation

Necessity of tuning the dataset selection

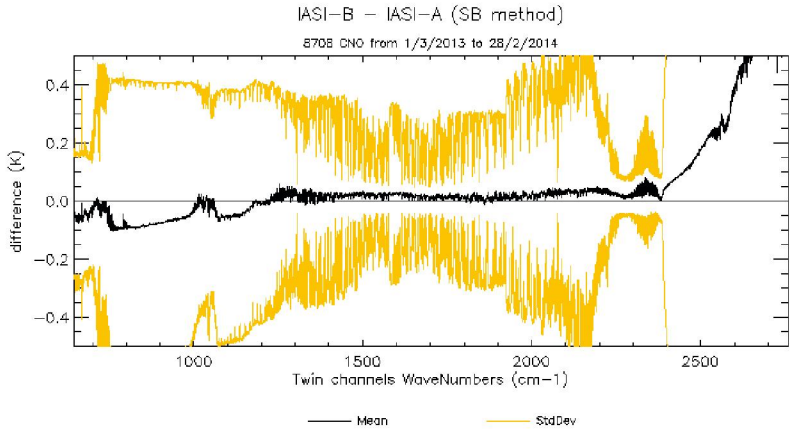
Nominal case (night, oceans, as many “A before B” as “A after B”):



Only “A before B”:

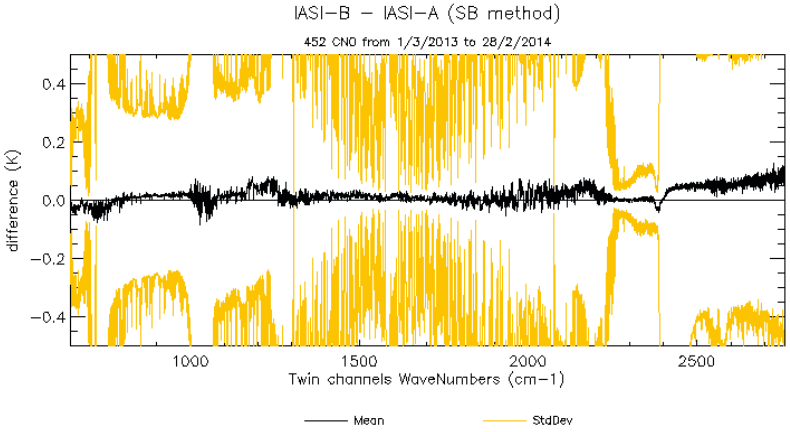


Only diurnal data:



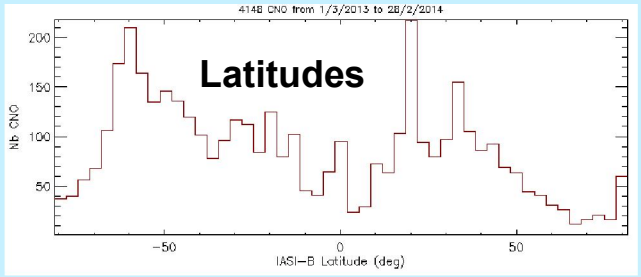
Stringent quality index:

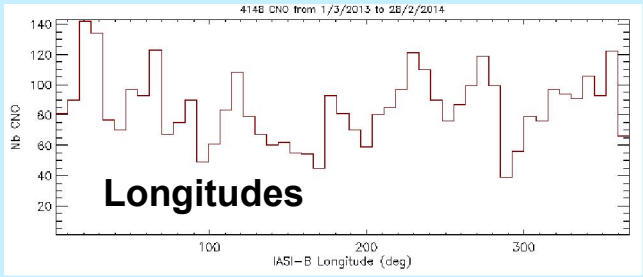
➔ Standard deviation mainly due to geophysics

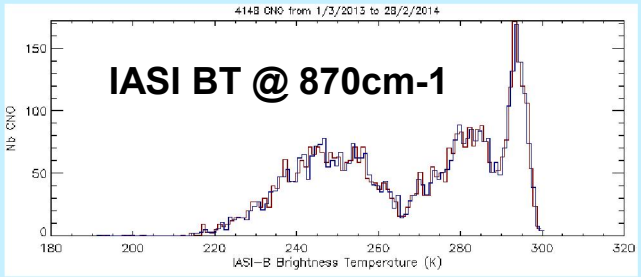


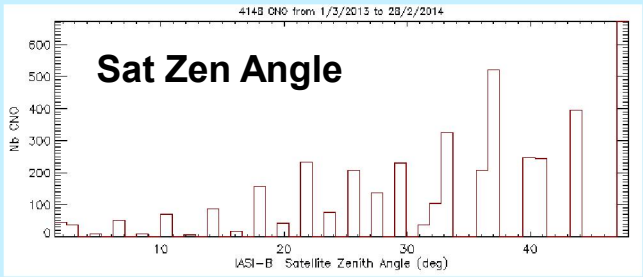
➔ Major impact of the input dataset, all parameters must be balanced

Features of the selected dataset



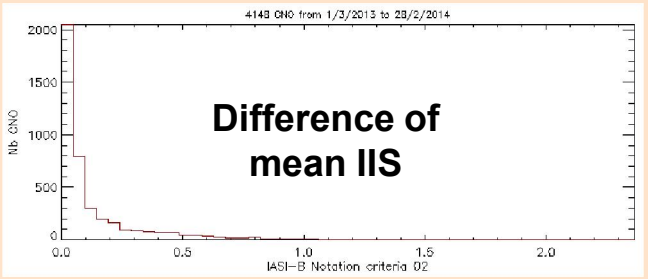


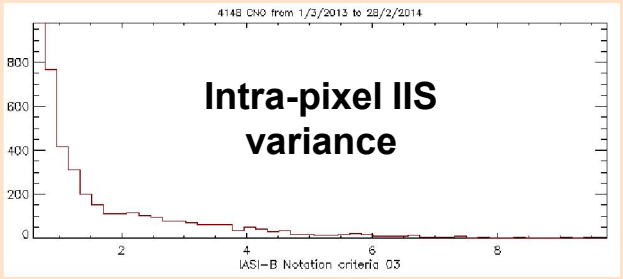


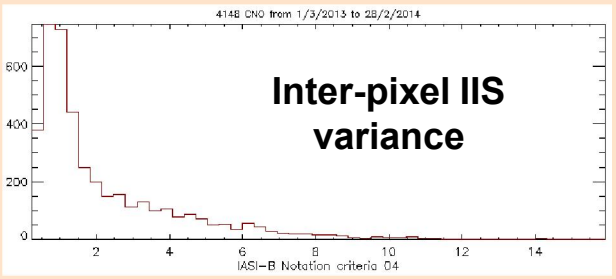


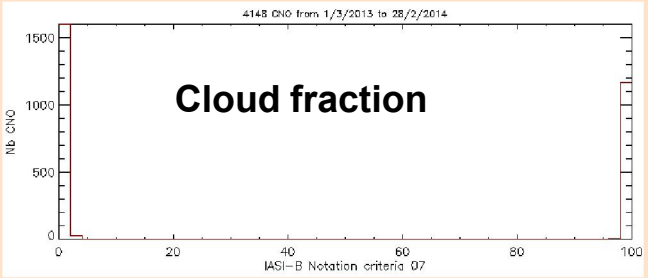
Goal for these parameters: diversity

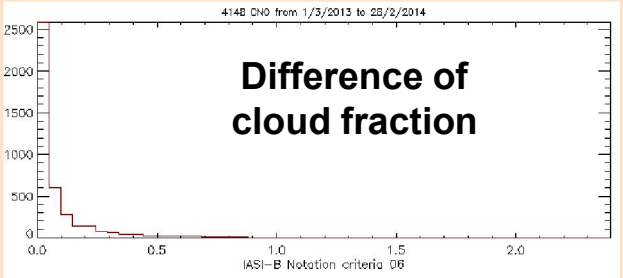
Goal for these parameters: minimization

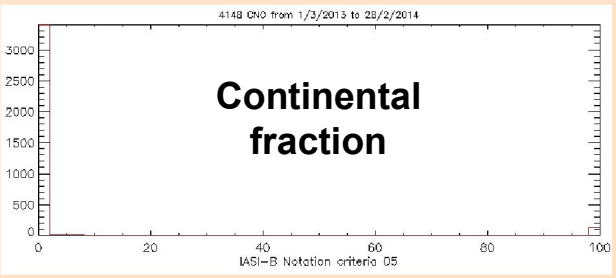






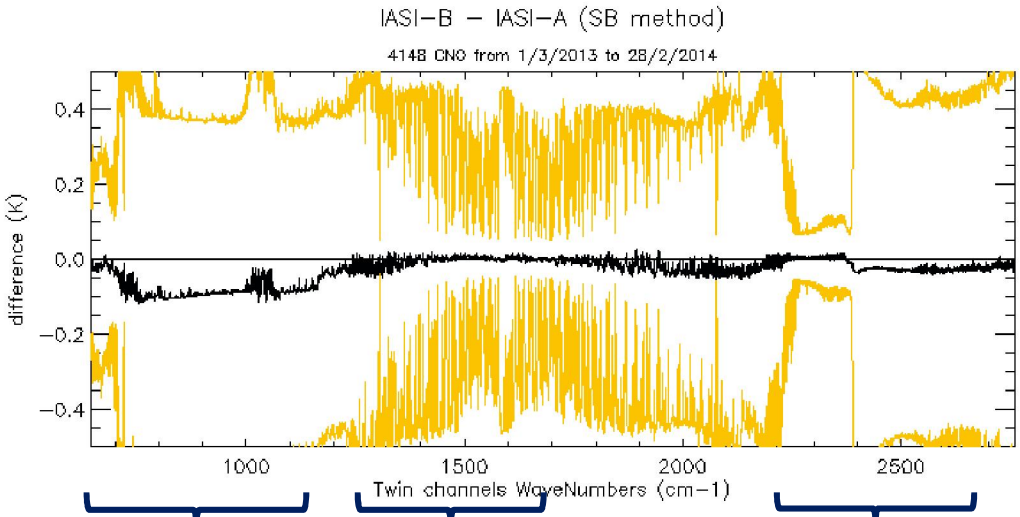




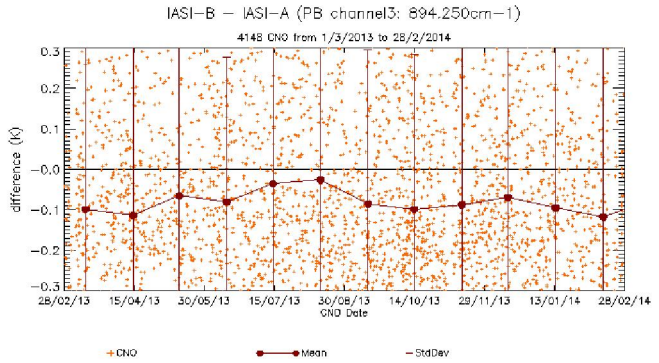


Direct IASI-A / IASI-B inter-comparison: results

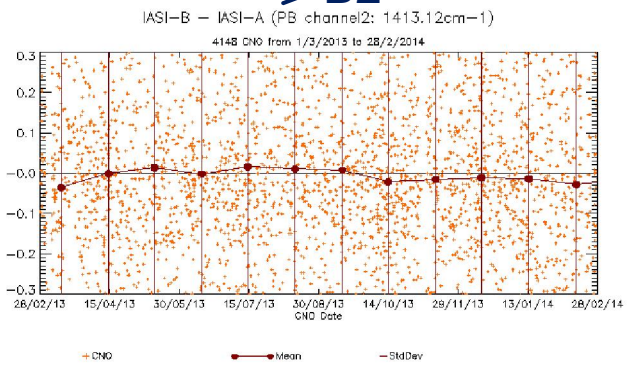
- The inter-comparison IASI-B / IASI-A is very stable with time



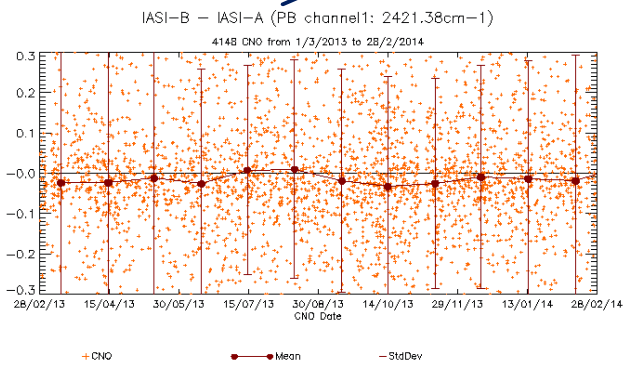
B1



B2

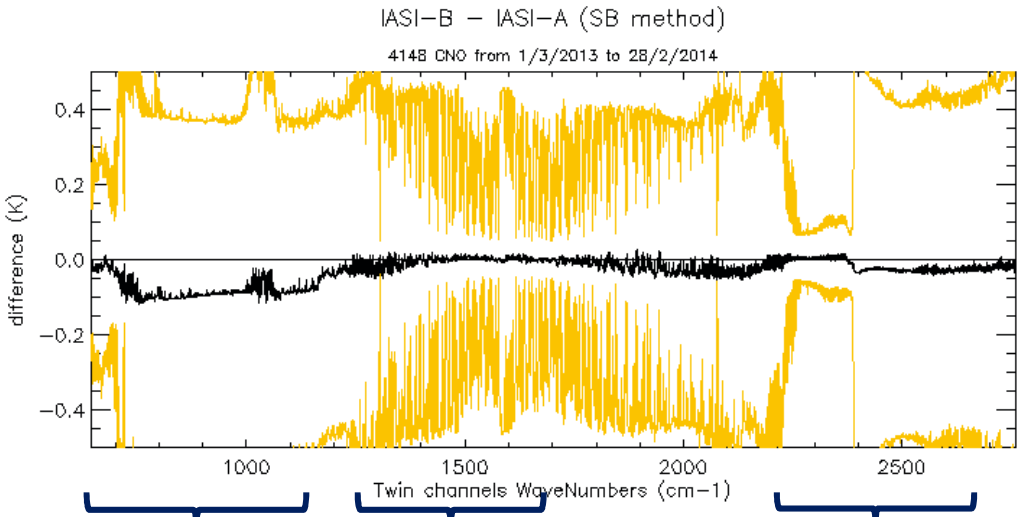


B3



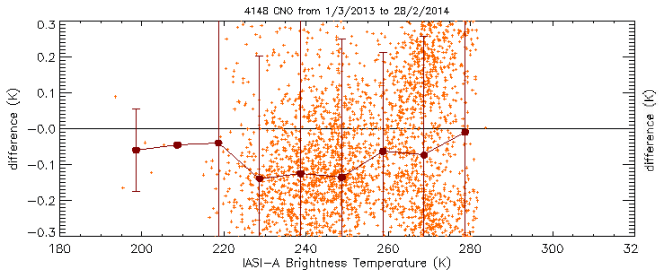
Shape in B1 under investigation

- Is the effect in B1 due to non-linearity?

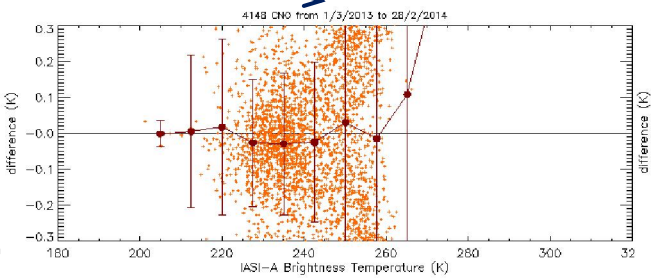


- Small increase in B1, amplitude ~+0.1K
- ➔ Slight non-linearity?
- ➔ Under investigation

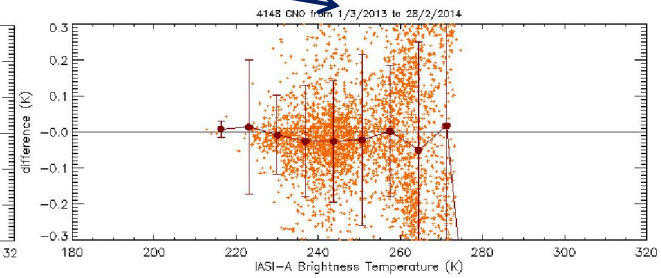
B1



B2



B3



NB: Be aware of the cross variations of some parameters (latitude / Scan Position / surface temperature / A before or after B)

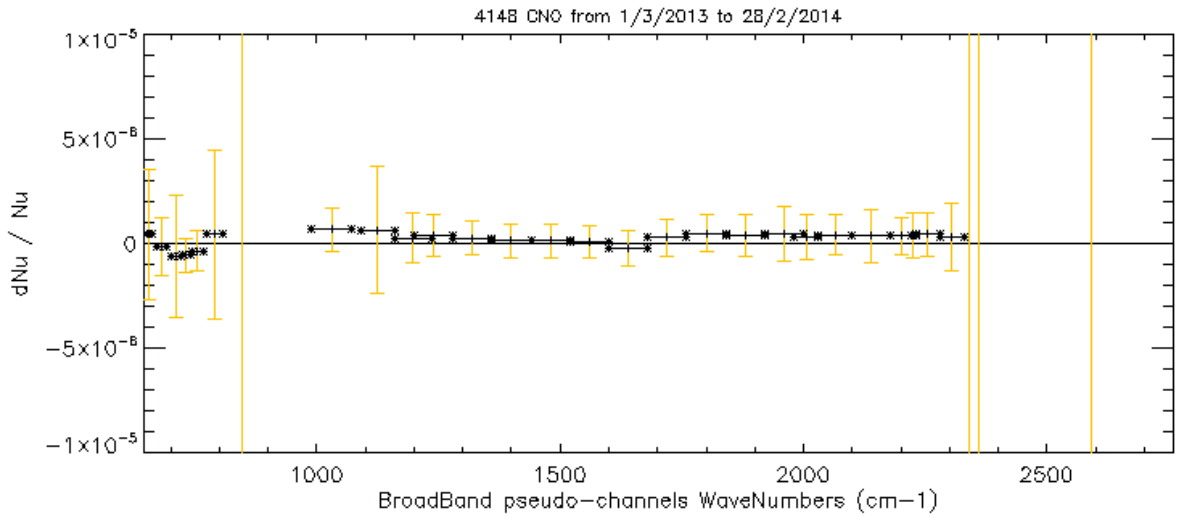
Direct IASI-A / IASI-B spectral inter-comparison

- **Specification for each IASI: Δv/v < 2 ppm** (~1% of the spectral sampling)

- **Methodology:**
  - **Definition of 30 spectral windows**
  - **For each window, cross-correlation of the IASI-A and -B spectra for different spectral shifts**
  - **The maximum of correlation gives the actual spectral shift**

- **Based on the same dataset as the radiometric calibration**

- **Results:**

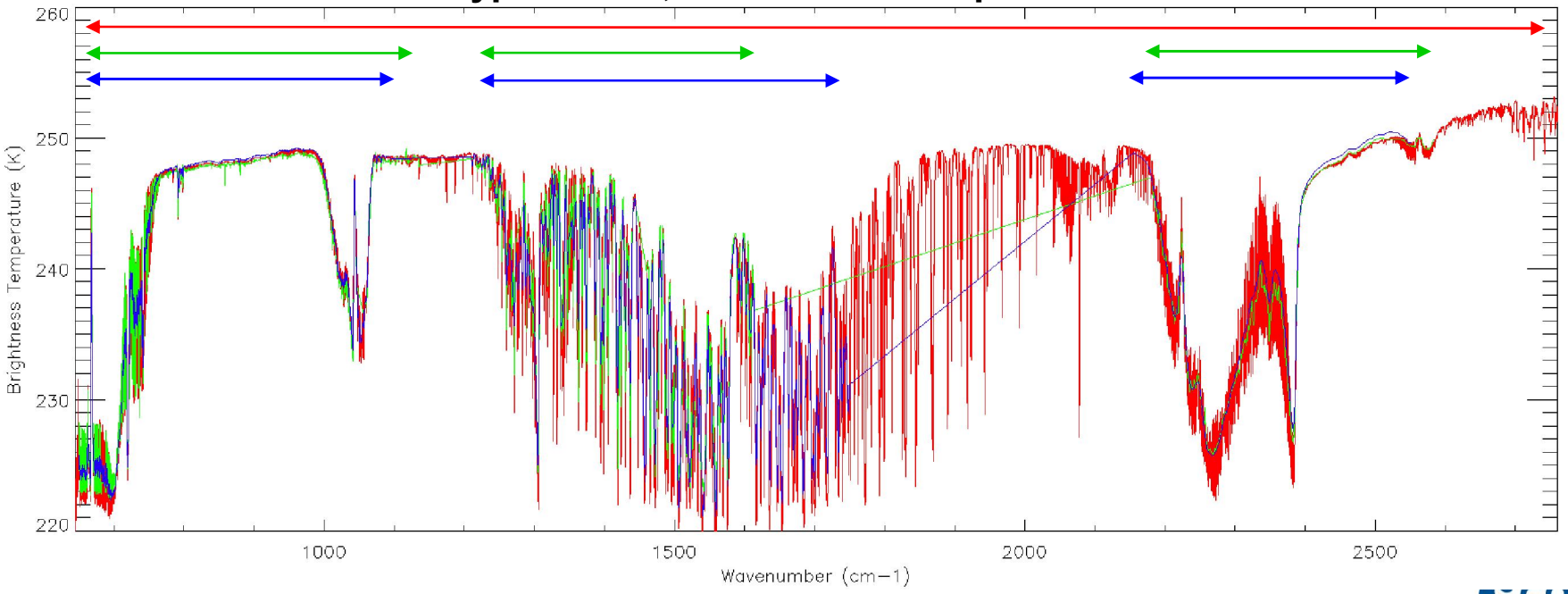


➔ **Performances largely compliant with the requirement**

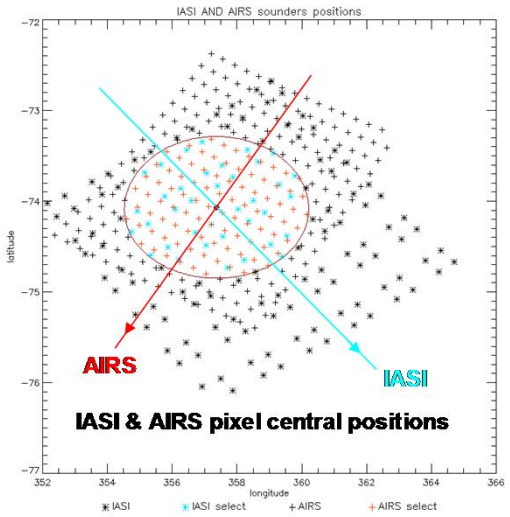
Reminder of AIRS, IASI, CRIS characteristics

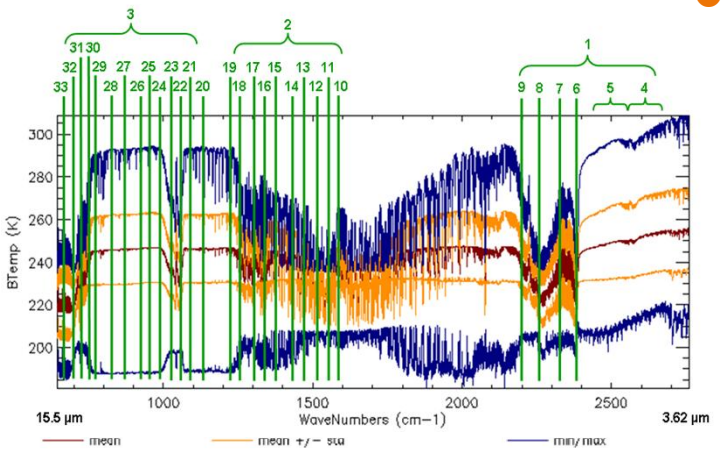
Instrument	IASI-A	IASI-B	AIRS	CRIS
Satellite	Metop-A	Metop-B	Aqua	NPP
Launch date	2006	2012	2002	2011
Local time	21h30		13h30	
Techno	FTS		Grating	FTS
Spatial resolution (nadir)	12 km		14 km	
Spectral range	645 – 2760 cm^{-1} / 3.62 – 15.5 µm			
Number of channels	8461		2378	1305
Spectral coverage	Continuous		Partial	
Spectral resolution	0.5 cm^{-1}		0.4 – 2.1 cm^{-1}	>0.625 – 2.5 cm^{-1}

Typical IASI, AIRS and CrIS spectra



Methodology for IASI / AIRS, IASI / CrIS





- **Similar scenes: SNOs** (Simultaneous Nadir Overpasses)
  - ✦ Tolerance in simultaneity : 20 min
  - ✦ ~30 scenes every 3 days for IASI / AIRS (12000 in 5 years)
  - ✦ Always at high latitudes

- **Spatial match:**
  - ➔ Regional averaging of the soundings pixels over a 300km*300km area around the orbit crossing point

- **Spectral match:**

  Construction of 33 broad pseudo-bands
  - ✦ Each PB = intelligent averaging of ~100 elementary channels to get the similarity of the PB spectral functions
  - ✦ The AIRS missing channels and varying spectral resolution are considered when calculating the IASI coefficients

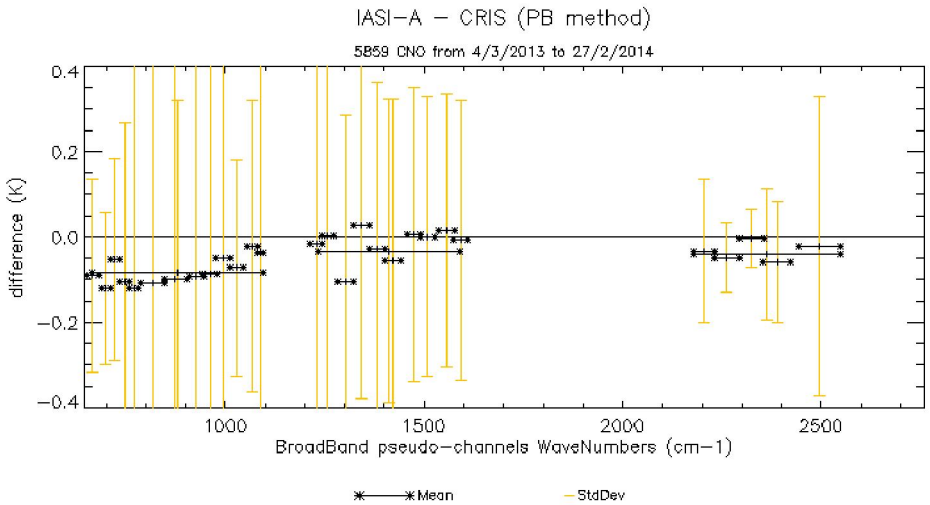
  NB: the convolution of IASI by the CrIS or AIRS ISRFs has been performed but is still under exploitation

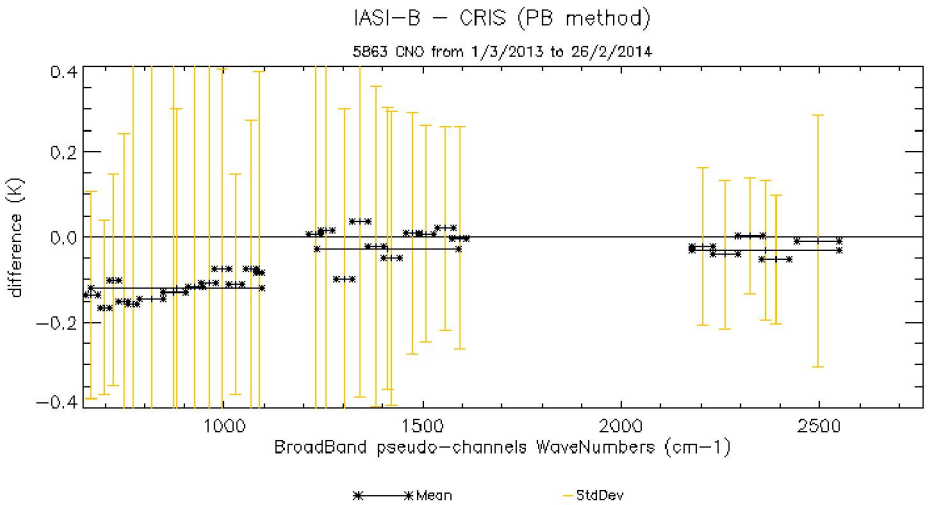
- **For each pseudo-band,** $\Delta T = \left(L_{IASI} - L_{AIRS}\right) \Big/ \frac{\partial L_\sigma}{\partial T}(\sigma, 280K)$

  ➔ Mean and stdev computed over the dataset

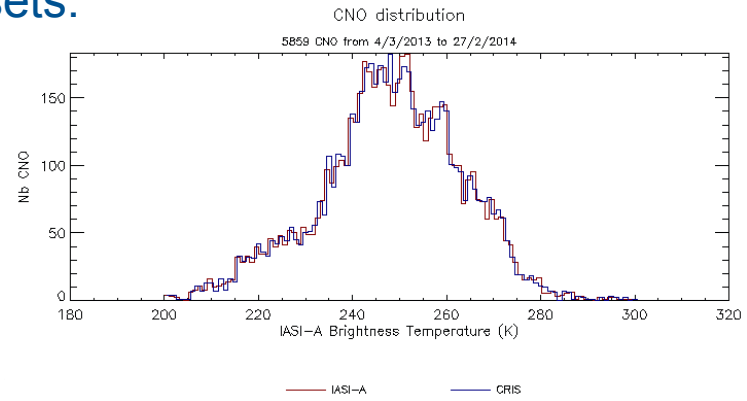
IASI-X / CrIS

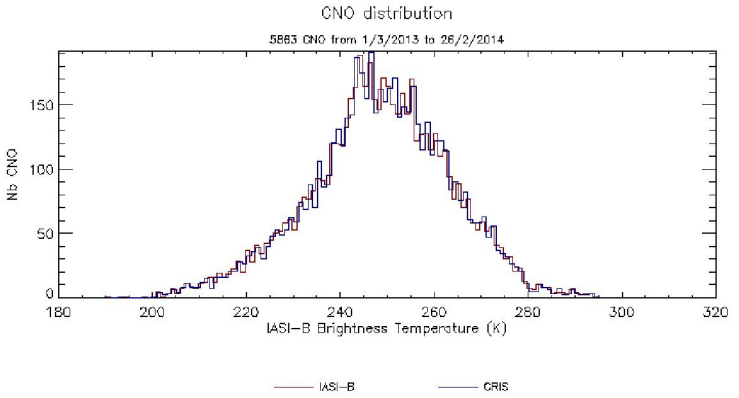
- Biases and standard deviations (no filtering)





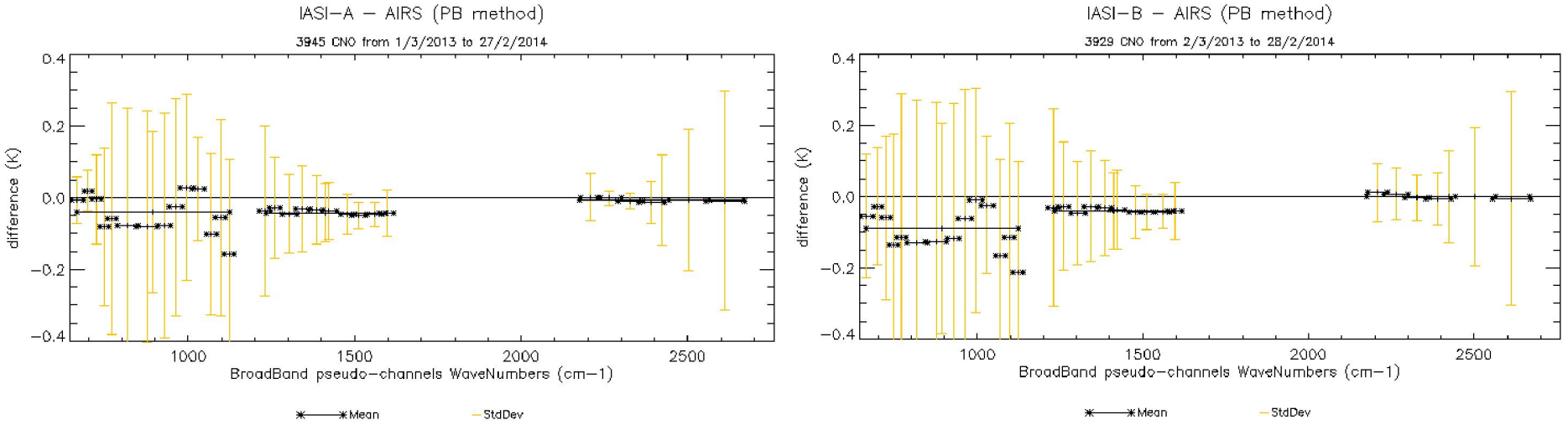
- Biases < ~0.2K ➔ Very well cross calibrated
- Same shape, highest bias in B1, stronger for IASI-B. Spectral slope?
- Similar datasets:



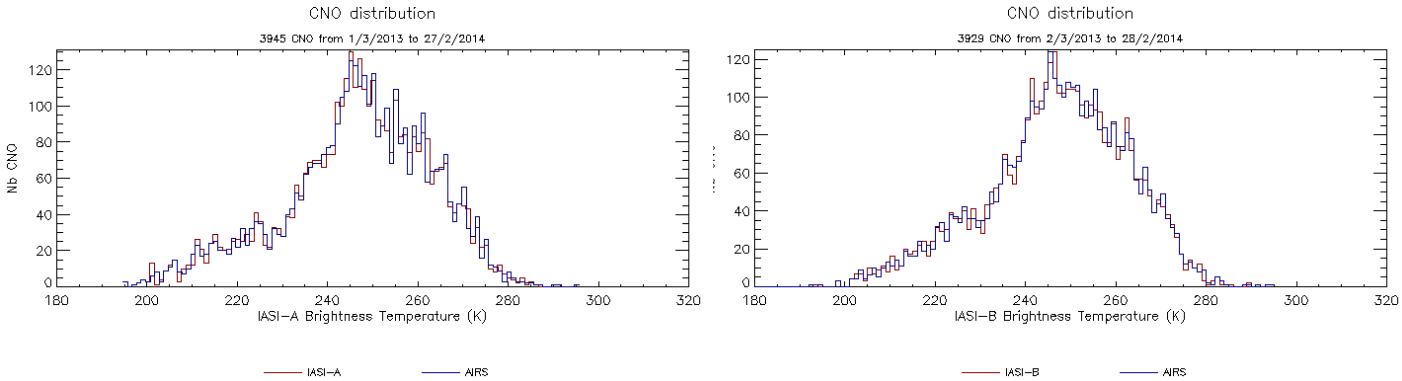


IASI-X / AIRS inter-comparison

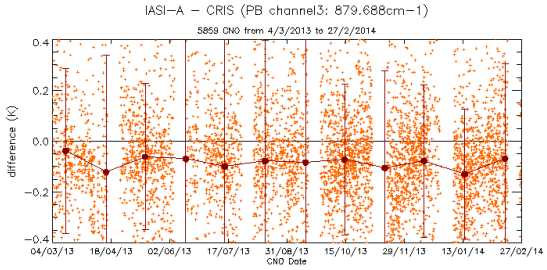
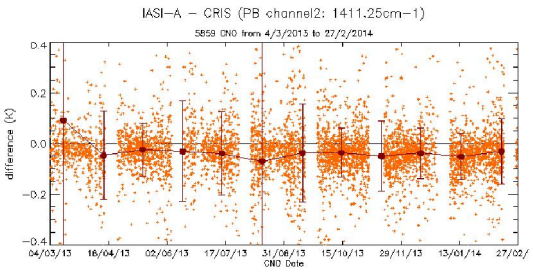
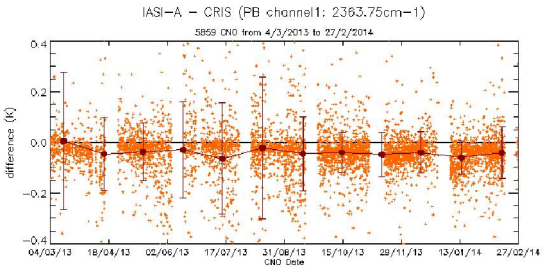
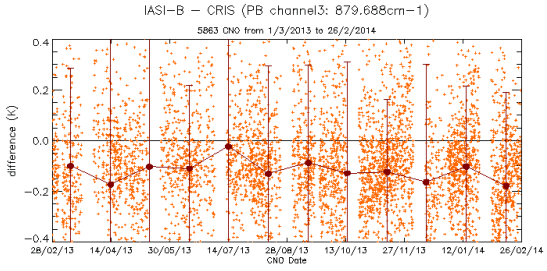
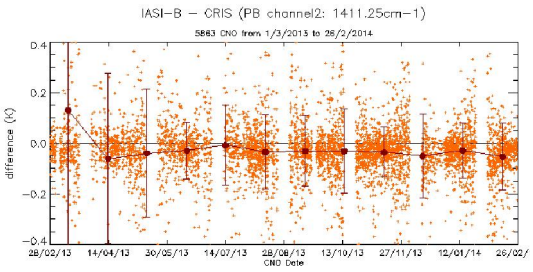
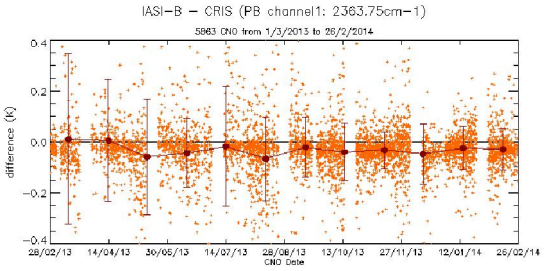
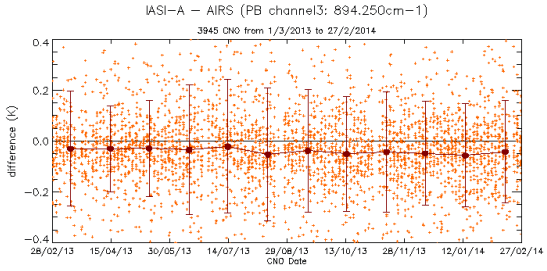
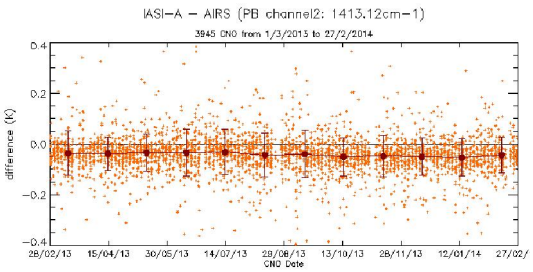
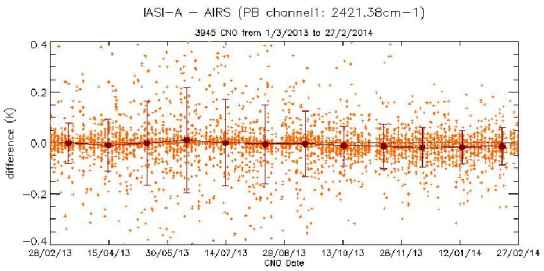
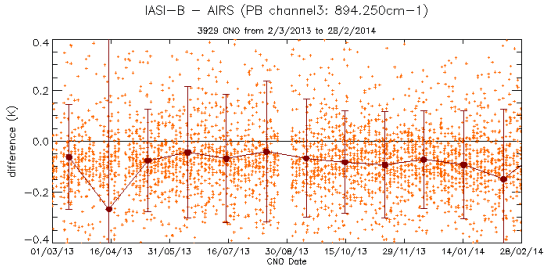
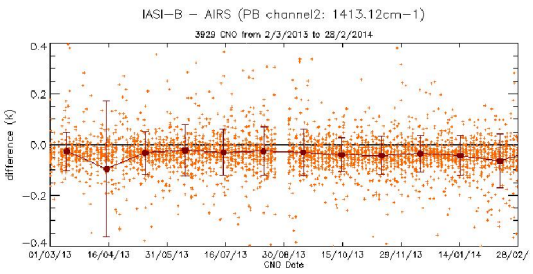
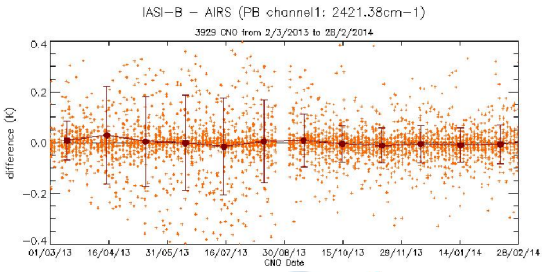
- Biases and standard deviations (no filtering)



- Biases < ~0.2K ➔ Very well cross calibrated
- Same shape, highest bias in B1, stronger for IASI-B. Atmospheric shape?
- Similar datasets:



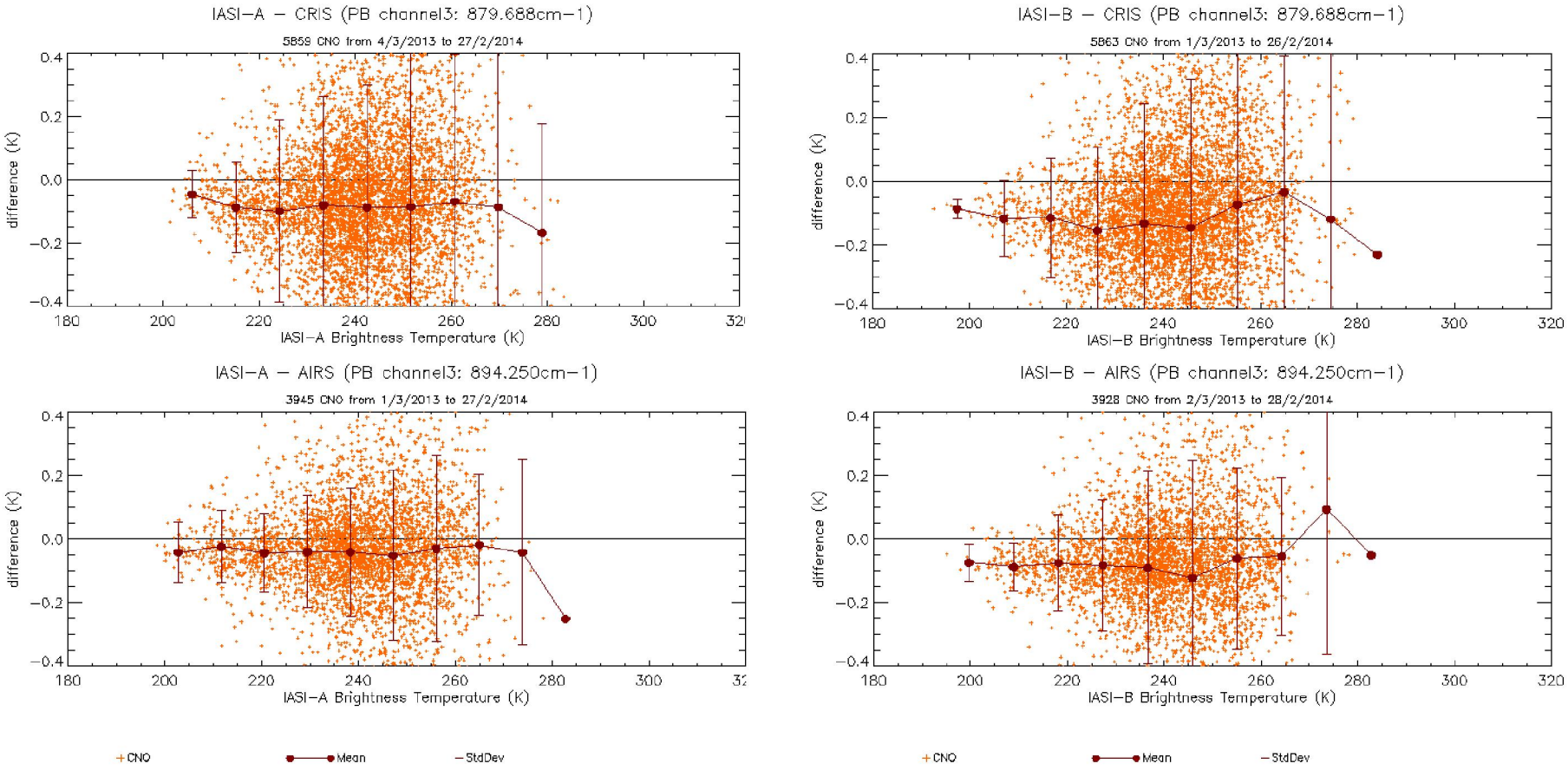
Temporal Evolution of IASI/AIRS and IASI/CrIS

	B1	B2	B3
IASI-A / CrIS			
IASI-B / CrIS			
IASI-A / AIRS			
IASI-B / AIRS			

➔ All couples are very stable with time

Non-linearity effects of IASI/AIRS and IASI/CrIS ?

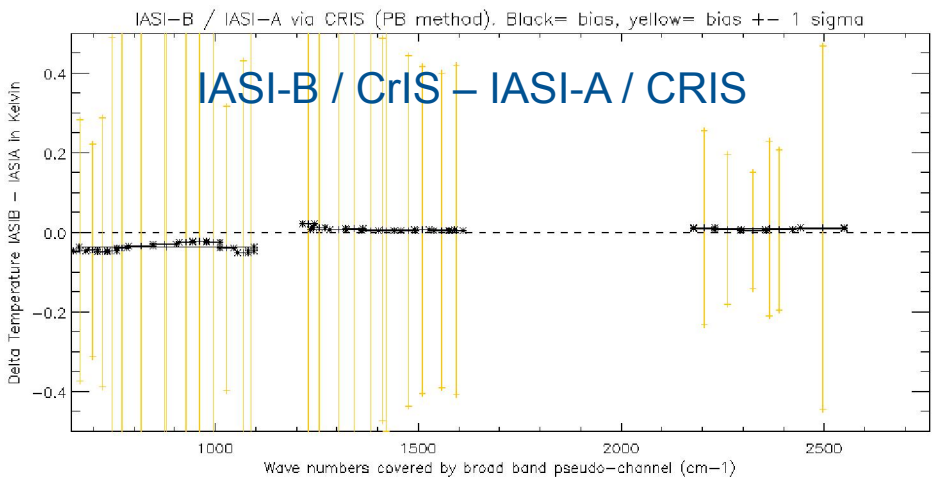
- Trend of B1 NeDT wrt B1 BT

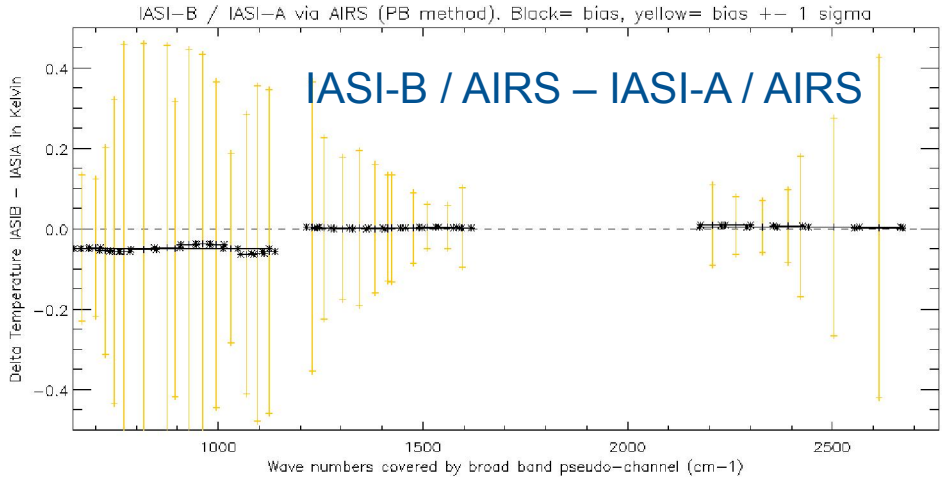


➔ No obvious effect

Indirect IASI-A / IASI-B through AIRS and CrIS

- Combination of IASI / AIRS and IASI / CrIS for IASI-B / IASI-A

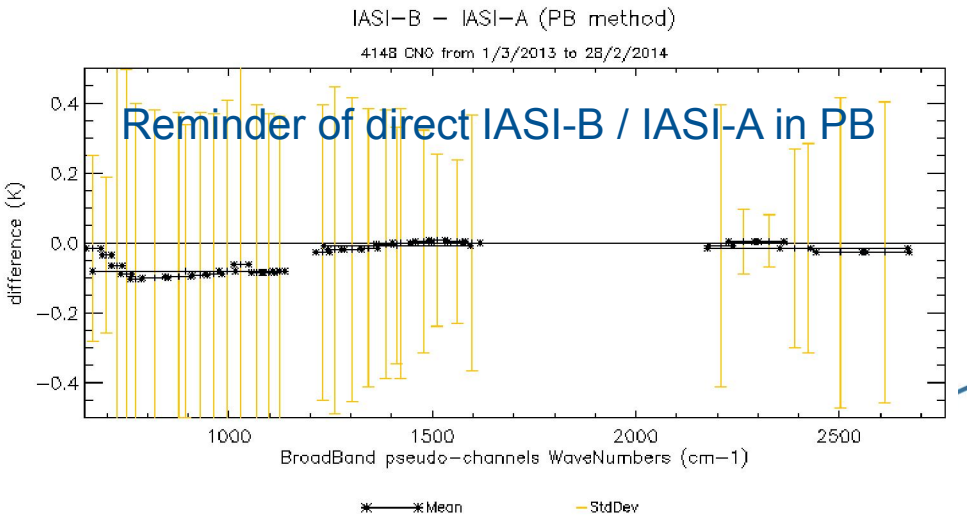




- All biases agree: ~0.1K

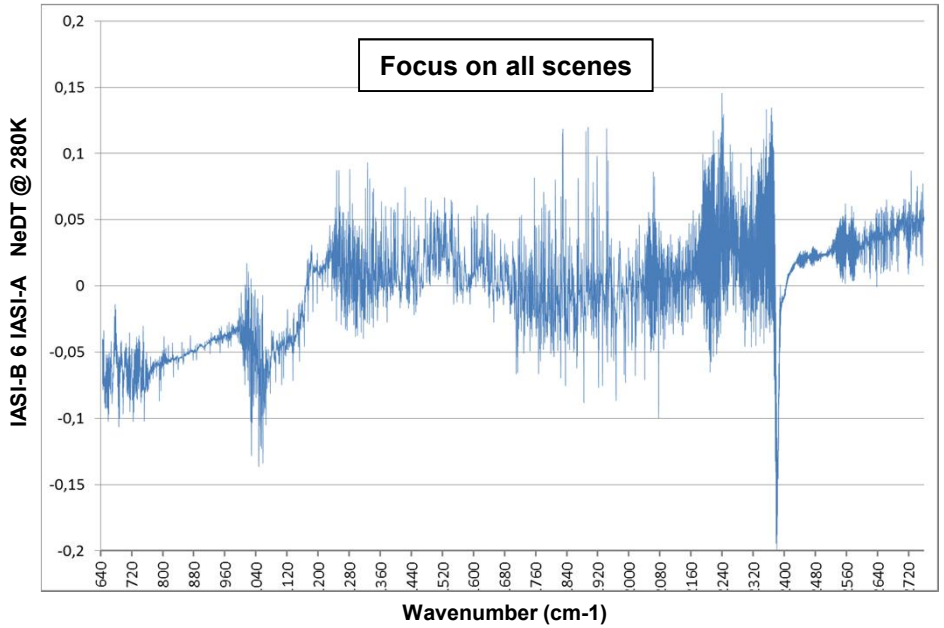
➔ Confirms the very good cross calibration

- Always an effect on B1, IASI origin?
- Small differences in B1: dataset selection, e.g. colder?



Difference of massive means IASI-B - IASI-A (from T. Phulpin)

- **Independent method: averaging of all L1C radiance spectra for IASI-B and IASI-A**
- **Data from June 2013 to February 2014, via Ether, OBRstat tool**
  ~65% cloudy; surf. temp. distrib. (1σ): 250K-290K
- **Difference IASI-B – IASI-A (NEDT) from these mean radiances:**



- ➔ **Same amplitude (bias ~0.1K in B1) and same shape as IASI-B / IASI-A direct comp.**
- ➔ **High confidence in this result**
- ➔ **Influence of the dataset: here also the input dataset may be a bit different between A and B (Ext. Cal., different AVHRR cloud flags, etc.)**

CONCLUSIONS

- **The tool for inter-comparison is operational for the 5 couples of sensors:**
  IASI-A / IASI-B, IASI-A / AIRS, IASI-B / AIRS, IASI-A / CrIS, IASI-B / CrIS

- **Major result: very accurate cross-calibration!**
  - **IASI-B very close to IASI-A (bias < ~0.1K) ➔ continuity of the IASI mission**
  - **IASI / AIRS / CrIS: Bias between 0K and 0.2K, < radiometric absolute specification of 0.5K**
  - **Cal/val results are confirmed with a larger and more diverse dataset**
  - **All are very stable with time**
  - **The observed bias is still high with respect to climatic time series**
  - **Largest bias in IASI B1, stronger in IASI-B: non-linearity in IASI?**

- **On-going work:**
  - **Go further in the interpretation of the shape of the bias curves:**
    - **Specific sensitivity studies for B1 are scheduled**
    - **Update of the linearity tables**
    - **Get the bias curves for each IASI pixel**
  - **Complete uncertainty budget**
  - **Go further in an absolute radiometric and spectral calibration**

cnes